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Fetal heart rate deceleration index – Its relation with fetal pH, Apgar score and dips or decelerations

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1 Introduction

It is generally agreed that continuous recording of the fetal heart rate (FHR) is of great value in the diagnosis of the intrauterine fetal condition; especially during labor. The classification and nomenclature of the alteration patterns of the FHR vary, and it is easy to get confused.

HON and others [7, 8, 9, 10] have classified transitory episodes of bradycardia into early, late and variable decelerations, according to the uniformity of the descents and their relation to the beginning of uterine contraction. They established degrees (mild, moderate and severe) according to the amplitude and duration of the descent [12] and related them to the fetal acid-base status, the newborn conditions, emphasizing the value of monitoring for neonatal respiratory distress [11]. On the contrary, CALDEYRO-BARCIA et al. [5] talk about dip I and II depending on lag time between the top of the contraction and the bottom of the FHR descent. All the authors pay particular attention to the relation between the FHR descents and uterine contractions. However, BAUMGARTEN [3], SUREAU [16] and others have demonstrated, that, what is an early deceleration for the HON group, could be considered a dip II by the Montevideo group.

Other authors take into consideration the end of the contraction and of the FHR descent [16]. There are also numerous changes that cannot be easily included within well defined patterns and whose importance has not been clarified. Besides, not all of the authors agree upon the innocuousness of the early dips [3, 16] because they could be intense and could be associated with acidosis.

Thus there is confusion concerning the accepted patterns and their significance for the fetus. We lack quantitative measures easy to define, in order to give a certain value to every transitory episode of bradycardia which can thus be correlated more closely with the fetal condition. There is general agreement about the importance of lag time, amplitude and duration of the deceleration.

It has been attempted to evaluate the decelerations of the FHR only by their area -i.e. dip

Curriculum vitae

PEDRO ACIEN, *M.D., was born in 1944. He studied medicine at Granada University, where he graduated in 1968. He specialized at the Department of Obstetrics and Gynecology, University of Granada College of Medicine (Prof.* V. SALVATIERRA*) and there has continued as teacher and staff member. Now he is "Jefe de Sección". His doctoral thesis dealt with perinatal medicine in 1973 and he received the „extraordinary award". He is mainly interested in research in Perinatal Medicine.*

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area- [14, 17], or by measuring the residual area [16]. CALDEYRO et al. [6] established the relation between the "amplitude units" of the dip II and the APGAR score of the newborn, and BEARD et al. [4] obtained a relationship that was not significant between the pH of the fetal blood and the lag time, and a less significant relationship between the pH and the amplitude of the decelerations.

We are trying to introduce a new index –Deceleration Index– [1] which is objective, easy to use and with which it is possible to give a numerical value to every transitory descent of the FHR in any of its forms: early, late, variable or intermediate. Thus it is possible to have a better correlation with the fetal conditions and to be able to establish in advance and with enough certainty whether there is fetal distress or not.

2 Description of the deceleration index of the FHR

This is shown in Fig. 1. It is applicable to every transitory descent of the FHR related to uterine contractions during labour. The index consists of four parameters for the deceleration or dip with a recognized value as follows:

a) The delay between the beginning of the uterine contraction and the beginning of the FHR descent counted in seconds. The value of this delay, as a sign of fetal distress has already been emphasized by different authors [2, 9, 13].
b) The lag time between the top of the contraction and the bottom of the dip, is also in seconds. This is the method of measuring by which CALDEYRO proposed to classify dips I and II.

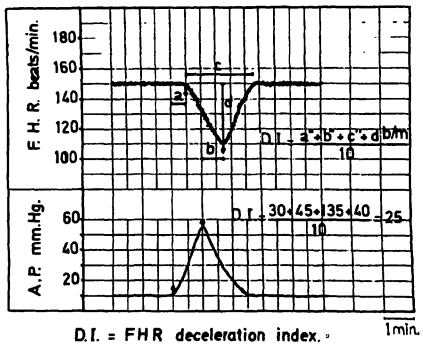

Fig. 1. Picture of the deceleration index and an example to show to calculate it.

c) The duration of the descent from its beginning up to the moment when the FHR returns to its normal value, is also expressed in seconds. With this parameter we specifically appraise the fetal ability to recover after the deceleration [7, 8, 16].
d) The amplitude of the transitory descent of the FHR expressed in beats per minute [4, 6].

We have proposed [1] that the deceleration index be calculated individually for every descent of the FHR, by adding the four above parameters and dividing the result by 10 to obtain a smaller numerical value easy to use.

3 Material and methods

We studied 42 patients, most of them at high obstetrical risk, whom we monitored during labor, recording FHR and uterine contractions, almost always with the fetal ECG by means of a scalp electrode and a transcervical catheter for measuring intrauterine pressure. In all cases we collected microsamples of blood from the fetal scalp during labor according to the SALING technique [15] and determined the acid-base status, hemoglobin, etc., at least once (66 microsamplings). We also made the same determinations after birth in blood from the umbilical artery and evaluated the APGAR score at the first and fifth minutes. All these cases were terminated by vaginal delivery in the cephalic presentation, and most of them received continuous intravenous Penthotal in the last phase of labor, with or without oxytocin. 18 women were primiparae and 24 multiparae.

In every case we studied 30 minutes of cardiotocographic recording before every blood sampling from the fetal scalp, and the 30 minutes before birth and calculated the deceleration index of the FHR described above, individually for every contraction-deceleration and their total in the 30 minutes.

The obtained values of the deceleration index in 30 minutes and the average index (total of the 30 minutes index divided by the number of contractions) have been correlated with: 1) the actual pH of the fetal scalp blood, pH evolution and the time passed up to the end of labor, 2) the actual pH of blood in the umbilical artery, and 3) the APGAR score at the first and fifth minutes.

According to the pH we formed three groups: normal (pH = 7.25 or more), preacidosis (pH = 7.20 to 7.24) and acidosis (pH = 7.19 or less). We also made three groups according to the APGAR score: normal or vigorous (7 or more), moderate depression (6–4) and intense depression (3–0); and finally, we made another three groups for the deceleration index in 30 minutes: 150 or less, from 151 up to 200 and more than 200. The same was done for the average index: 15 or less, from 16 to 20 and 21 or more.

In all cases, we used the square chi test it with and without YATES correction and then we calculated the average from both results. We also calculated the correlation coefficients of the deceleration index against the pH and the APGAR score and the confidence limit for 95% after its "z" transformation.

4 Results

4.1 Relation between deceleration index (D.I.) and pH

In the cases studied by us, the four parameters of the D.I. were negatively correlated with the fetal pH. This correlation was more significant for the duration of the transitory bradycardia (c) (r = −0.56), less significant for the amplitude (d) (r = −0.45) and lag time (b) (r = −0.42) and not significant for the delay between the beginning of the contraction and descent of the FHR (a) (r = −0.29). The addition of the 4 parameters has permitted us to obtain better correlation with the pH (r = −0.719).

The left side of Fig. 2 shows the first actual pH determination from fetal scalp blood, cervical dilatation at that moment and the deceleration index from the previous 30 minutes. The right side shows the evolution of the pH in every case up to the umbilical artery according to the time passed and the value of the deceleration index during the 30 minutes previous to every blood sampling (circle) and prior to birth (point). It can be seen that already from the beginning, the cases with acidosis had high deceleration indexes and that those cases whose deceleration index increased later, also became acidotic. This occurred more quickly when the deceleration index was larger. The case in which the D.I. was 169 and the pH was 7.08 at the beginning of labor, was permitted to deliver naturally because the fetus had "hydrops fetalis".

Fig. 3 shows the relation between the pH of fetal scalp blood (circle) and that of the umbilical artery blood (point) and the deceleration index during the previous 30 minutes, as well as the

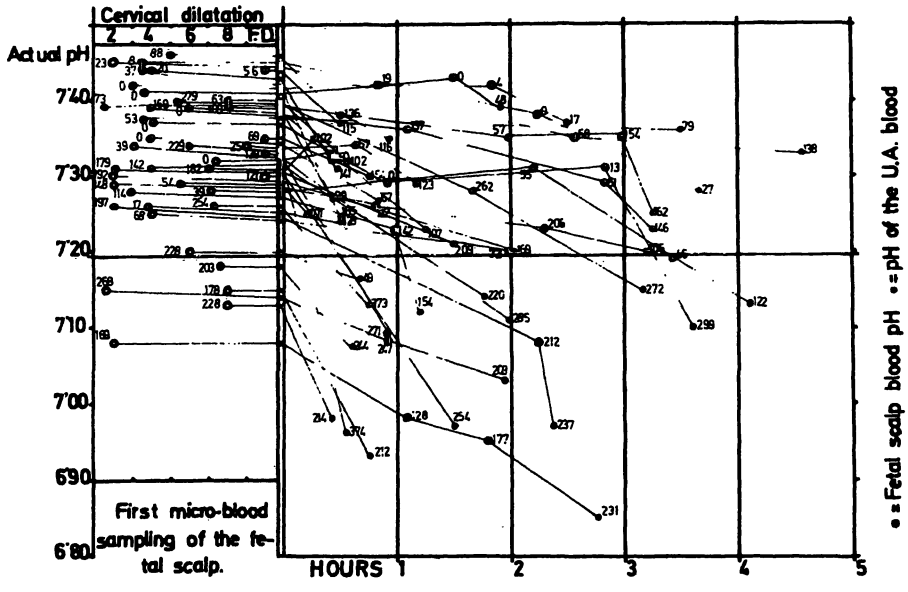

Fig. 2. Evolution of the actual pH up until birth in relation to the time passed, and with the value of the deceleration index during the previous 30 minutes on each microblood sampling and delivery.

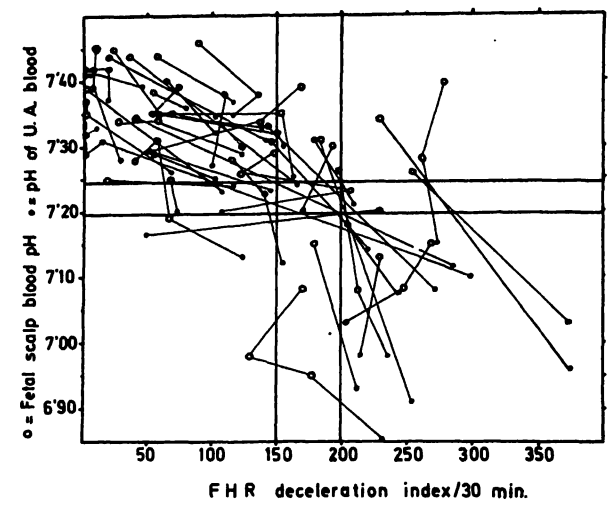

Fig. 3. Relation between the fetal pH and that of the umbilical artery and the deceleration index during the previous 30 minutes. The lines join a same case.

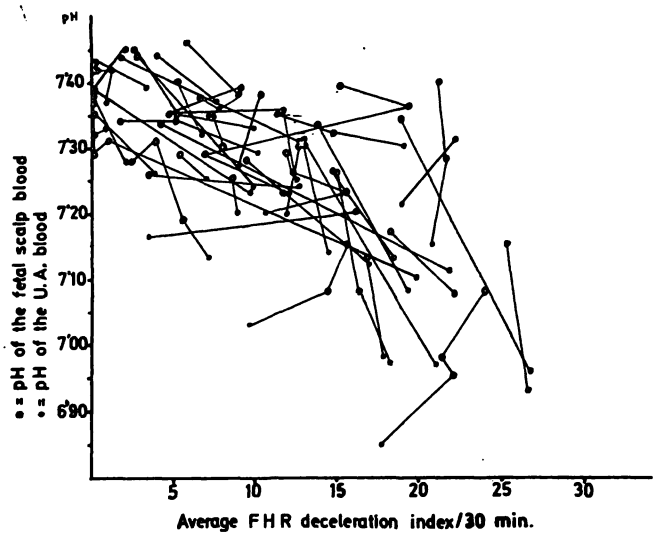

Fig. 4. Relation between the fetal pH and that of the umbilical artery and the average deceleration index per contraction in the previous 30 minutes. The lines join a same case.

evolution of both parameters (pH and D.I.) in the 42 cases studied. The continuous lines join the same case. The tendency to acidosis can be observed when the deceleration index increases. All cases with a deceleration index of more than 200 had acidosis in the umbilical artery except one with preacidosis. The square chi test for the pH and deceleration index groups is statistically significant. In some cases in which the deceleration index was high at the beginning and there was no acidosis, afterwards, even when the deceleration index diminished, the fetus was born with acidosis.

Fig. 4 shows just the same relationships but in relation to the average deceleration index per contraction. The pH behaviour according to this parameter is similar.

In Tab. I the maximum deceleration index found in any of the 30 minutes periods (before blood sampling from the scalp and before delivery) is correlated with the pH in the umbilical artery. It can be seen that if the deceleration index was less than 150, only one case had acidosis (there was severe fetal tachycardia). If the deceleration index from the 30 minutes was more than 200 all the cases ended up with acidosis except one with preacidosis. The square chi test is highly significant ($p < 0.0005$). In Fig. 5 we show the correlation between the parameters studied in the preceding table. Here also, the correlation coefficient is statistically very significant ($r = -0.719$; $p < 0.001$).

Tab. II shows the relation between the maximum average deceleration index observed in a period of

Tab. I. Relation between the maximum D.I. observed in a period of 30 minutes in each case, and acidosis in the blood of the umbilical artery. The square chi test was used.

Maximum	pH of the umbilical artery			
D.I./30 minutes	Normal No. (%)	Preacidosis No. (%)	Acidosis No. (%)	Total
Less than 100	6 (85.7)	1[x] (14.3)	–	7
101–150	9 (75.0)	2 (16.6)	1[⊕] (8.3)	12
151–200	2 (33.3)	3 (50.0)	1 (16.6)	6
201–250	–	1 (11.1)	8 (88.8)	9
More than 250	–	–	8 (100)	8

Chi^2 test = 32.015; $p < 0.0005$
x = a case of eclampsia. ⊕ = a case of severe fetal tachycardia.

Tab. II. Relation between the maximum average index and the pH in the umbilical artery.

Maximum average D.I./30 minutes	pH of the umbilical artery Normal No. (%)	Preacidosis No. (%)	Acidosis No. (%)	Total
5 or less	5 (100)	–	–	5
6–10	9 (62.3)	3x (23.1)	1⊕ (7.7)	13
11–15	2 (40.0)	2 (40.0)	1 (20.0)	5
16–20	1 (9.1)	1 (9.1)	9 (81.8)	11
21 or more	–	1 (12.5)	7 (87.5)	8

Chi^2 test = 29.942; $p < 0.0005$
x = a case of eclampsia. ⊕ ≙ a case of severe fetal tachycardia.

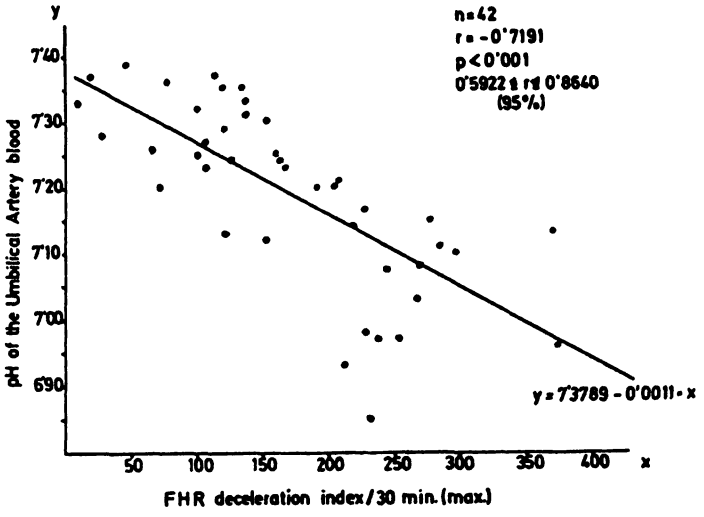

Fig. 5. Correlation between the maximum deceleration index observed during 30 minutes and the pH of the blood from the umbilical artery at birth.

30 minutes and acidosis in the blood of the umbilical artery. The square chi test is also highly significant here ($p < 0.0005$). The D.I. per contraction of more than 16 are generally associated with acidosis.

The correlation between these parameters is shown in Fig. 6 and is also very significant ($r = -0.762$; $p < 0.001$).

4.2 Relation between D.I. and APGAR score

The square chi tests for the relation between the maximum deceleration index during 30 minutes and the APGAR score from the first and fifth minutes are also significant, although it is not so high as the one found for the pH ($P < 0.05$ and $p < 0.01$).

In Figs. 7 and 8 we show the correlation between the deceleration index and the Apgar score which

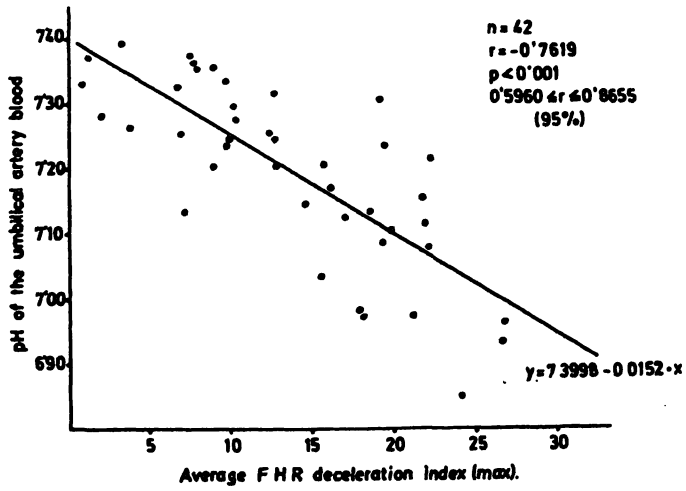

Fig. 6. Correlation between the maximum average deceleration index per contraction observed and the pH of the blood in the umbilical artery at birth.

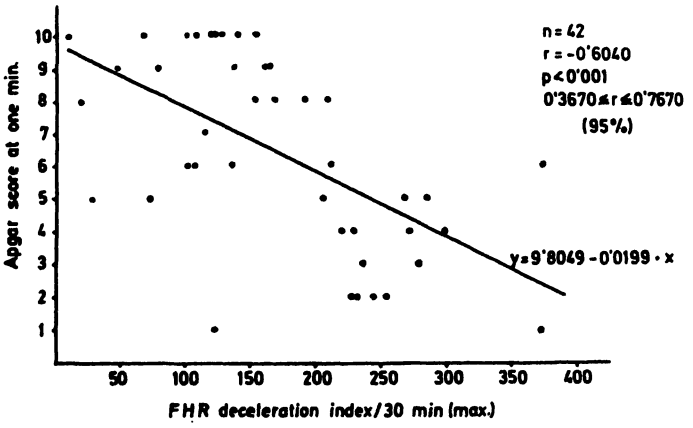

Fig. 7. Correlation between the maximum deceleration index observed during 30 minutes and the APGAR score taken at the first minute of life.

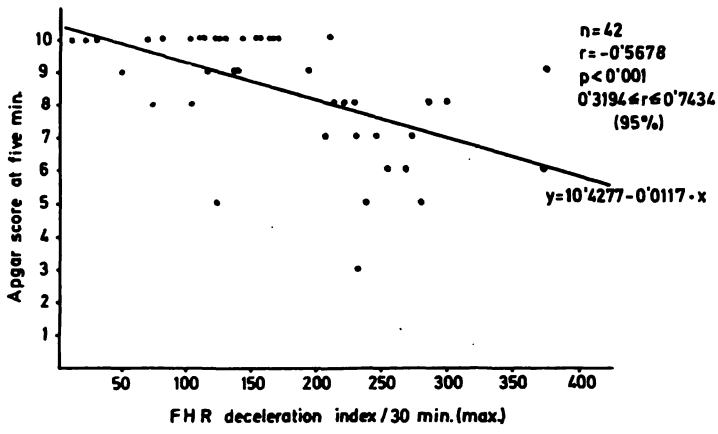

Fig. 8. Correlation between the maximum deceleration index observed during 30 minutes and the Apgar score taken at the fifth minute of life.

is also significant ($r = -0.604$; $p < 0.001$ and $r = -0.567$; $p < 0.001$).

4.3 Relation between D.I. and dips

In Tab. III, we show the average values and standard deviations of the deceleration index for every kind of dip (early –I–, variable or late –II–) in a total of 1251 contractions analysed.

Tab. III. Relation between the different types and degrees of dip and their corresponding deceleration indexes.

Dips	No.	Deceleration index	
		$\bar{x}$	s
I	222	8.61	3.26
Variable			
mild	86	12.66	3.49
moderate	54	16.66	2.82
severe	89	18.97	2.89
II			
mild	51	14.53	2.53
moderate	100	17.68	3.12
severe	114	25.12	4.35

It can be observed that the values of D.I. for the variable dips are a little smaller than those corresponding to dips II, in agreement with the previous idea about the significance of these parameters [12]. In Figs. 9, 10 and 11, some of the cases studied by us are shown.

5 Discussion and conclusions

The proposed deceleration index is easy to calculate and it improves the correlation existing between the principal parameters of the decelerations ("decalage", duration and amplitude) and the fetal pH. It also has the following advantages: 1) we give a numerical value to the transitory descents of the fetal heart rate, 2) by watching a cardiotocographic recording for a short time, we are able to appraise the possibility of intrauterine acidosis, because of its close correlation with the fetal pH, 3) any doubts about whether it is an early, late or variable dip are eliminated, and 4) it points out the value we think the early or I dips could have, by adding their values to the other alterations of the cardiotocographic recording. We think it is important to calculate the index for every deceleration and to add up the observations of half an hour. **If the index during the 30 minutes is less than 150 and there is no other FHR alteration (tachycardia, silent, etc.) or maternal alterations, we can conclude that there is no risk for the fetus. If the index is more than 200, there is a risk for the fetus which is nearly always born with acidosis. The values between 150 and 200 mean a moderate risk and requires a close watch. If the observation period is smaller and the deceleration index per contraction is more than 16, this must be considered dangerous for the fetus.**

Finally, we think that whenever we do not have the apparatus for the micro-blood sampling or it is technically impossible to perform, the evaluation of the deceleration index can be a great help.

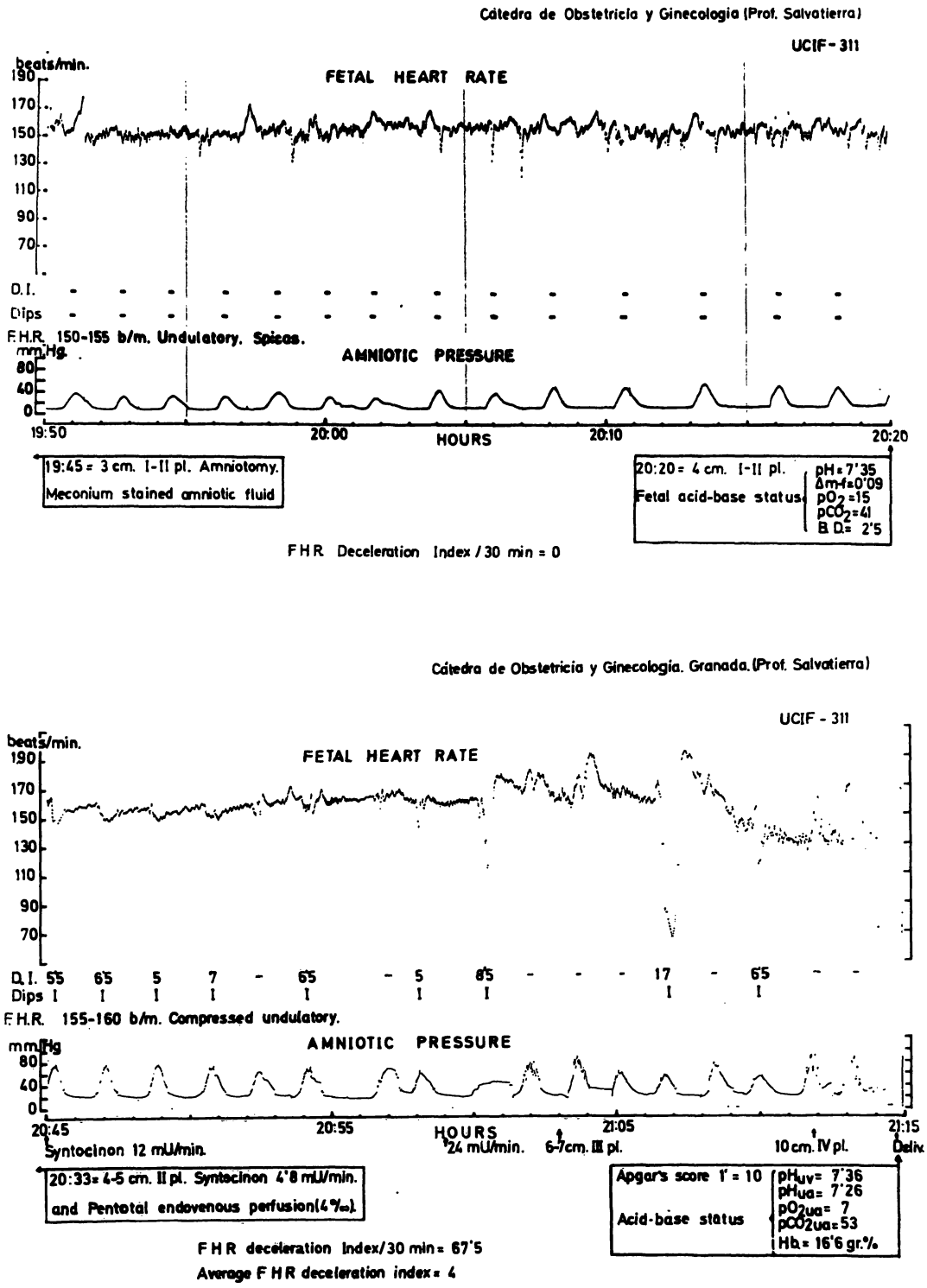

Fig. 9. A case with small deceleration index. The newborn was vigorous and without alteration in the acid-base status.

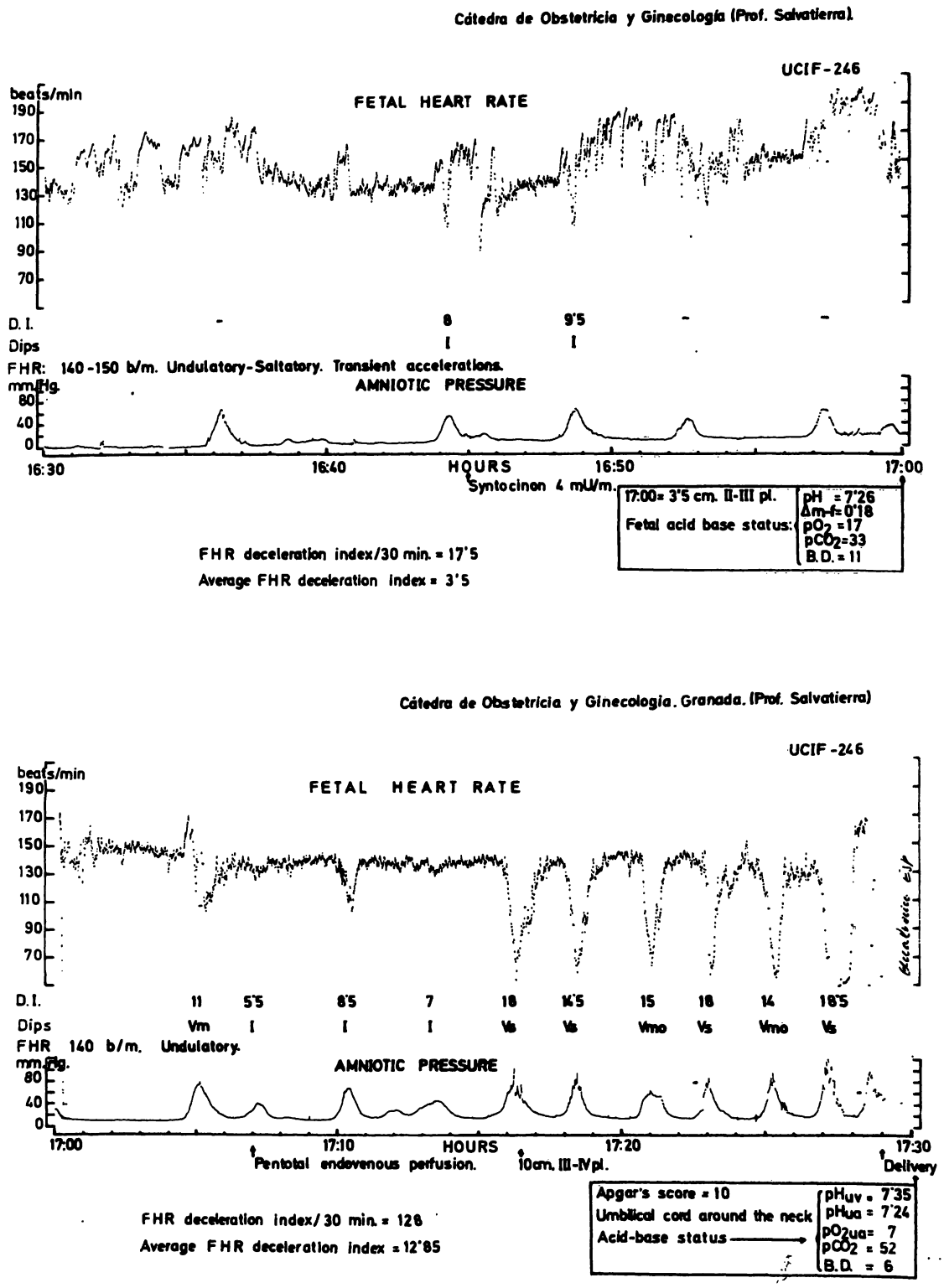

Fig. 10. Another case with the umbilical cord around the neck, but with deceleration index less than 150, and that was also born vigorous and with normal acid-base status.

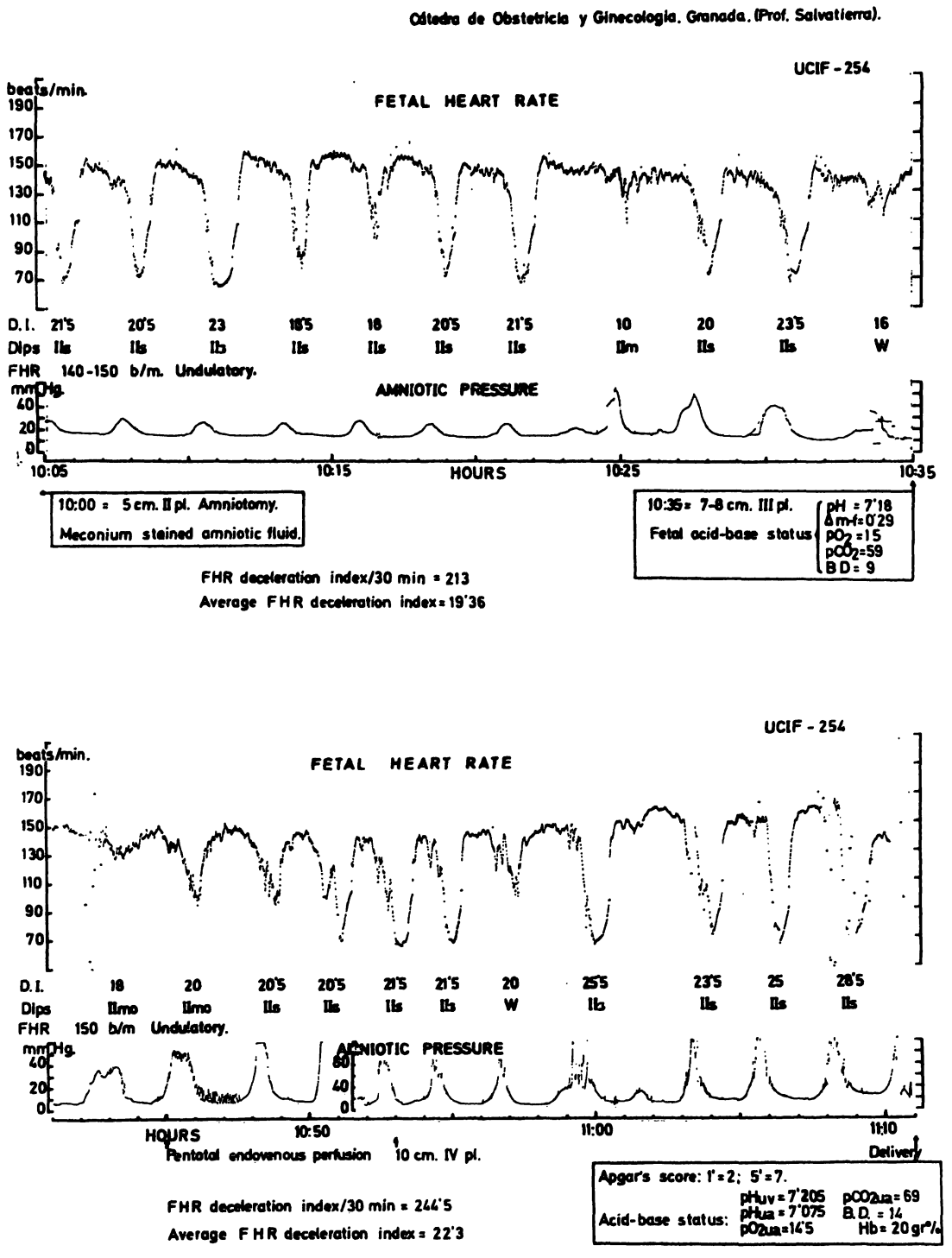

Fig. 11. A case with deceleration index high. Intrauterine acidosis and depressed newborn.

Summary

The authors propose a method for evaluating decelerations in the fetal heart rate (FHR deceleration index), which is easy to use and understand, gives them a numerical value that can be correlated with fetal and neonatal conditions, independently of the traditional cataloguing of these decelerations or dips.

The deceleration index consists of the following parameters (Fig. 1): a) the delay between the beginning of the contraction and the beginning of the descent of the FHR, b) the lag time between the top of the contraction and the bottom of the deceleration or dip, c) the duration of the descent up to the point when the FHR returns to its normal value, and d) the amplitude, counted in beats per minute. The sum of these parameters is divided by 10.

42 women were studied during labor by means of monitoring, using cardiotocographic cordings and taking blood samples from the scalp fetal. We also studied, after birth, the acid-base status of the umbilical cord blood and the APGAR score.

During the 30 minutes prior to every blood sampling and delivery, we evaluated the D.I. of every transitory descent and we added up the values of the 30 minutes. In Fig. 2 we show the changes of the actual pH in each case, according to the time passed and the value of the D.I./30 minutes. In Figs. 3 and 4 we show the relationship between the actual pH of every case and the D.I./30 minutes and its average per contraction, previous to every analysis. In general, when the deceleration index increases, the pH falls and all the cases that had D.I./30 minutes more than 200, ended up with acidosis in the umbilical artery except one with preacidosis. The correlation between the higher D.I./30 minutes in any of the studied periods and the pH of the umbilical artery is very significant (Figs. 5 and 6). The correlation with the APGAR score is a little lower (Figs. 7 and 8).

According to these studies, prognostic values of the deceleration index are given: **If the D.I./30 minutes is less than 150 and there is no other FHR alterations or maternal alterations, we can conclude that there is no risk to the fetus; if the index is more than 200 there is a risk for the fetus and it is nearly always born with acidosis.** The values between 150 and 200 indicate a moderate risk and also require a close watch (Tab. I).

The authors point out the importance that this index may have in the understanding of the fetal cardiotocographic cordings, specifically when we do not have the apparatus for micro-blood sampling or it is technically impossible to perform.

The average values of the deceleration index that correspond to the traditional patterns of the FHR, are also indicated (Tab. III).

Keywords: Apgar score, deceleration index, decelerations in the FHR, dips, fetal acid-base status, fetal heart rate, fetus, newborn.

Zusammenfassung

Beziehung des fetalen Herzfrequenz-Dezelerations-Index zu pH, APGAR-Punktezahl und Dezelerationen.

Die Autoren schlagen eine Methode zur Bewertung fetaler Herzfrequenz-Dezelerationen vor (fetaler Herzfrequenz-Dezelerations-Index, DI), die leicht zu verstehen und anzuwenden ist. Der DI gibt den Herzfrequenzveränderungen unabhängig von der traditionellen Einteilung der Dezelerationen einen Zahlenwert, der mit dem fetalen und neonatalen Zustand korreliert werden kann.

Der DI erfaßt folgende Größen (Abb. 1): a) den Zeitraum zwischen Kontraktionsbeginn und Beginn des Herzfrequenzabfalls, b) den Zeitraum zwischen Kontraktionshöhepunkt und Tiefpunkt der Dezeleration, c) den Zeitraum vom Beginn des Herzfrequenzabfalls bis zu dem Punkt, an dem die FHF zu ihrem Normalwert zurückkehrt, d) die Amplitude, gezählt in Schlägen/min. Die Summe dieser Parameter wird durch 10 geteilt.

42 Frauen wurden während der Geburt kardiotokographisch und fetalblutanalytisch überwacht. Nach der Geburt wurde der Säure-Basen-Status des Nabelschnurblutes und die APGAR-Punkte-Zahl erfaßt.

Wir berechneten den DI für jede Dezeleration und addierten diese Werte jeweils für 30 min vor jeder Blutentnahme und der Geburt. In Abb. 2 zeigen wir die Veränderungen des aktuellen pH jeden Falles in Abhängigkeit von der verstrichenen Zeit und den Werten des DI pro 30 min. In Abb. 3 und 4 ist das Verhältnis von aktuellem pH, DI pro 30 min und seinem durchschnittlichen Wert pro Kontraktionen zu sehen. Allgemein gilt, daß bei ansteigendem DI der pH absinkt. Alle Fälle mit einem DI pro 30 min mehr als 200 endeten mit einer Azidose im Nabelschnur-Arterien-Blut, abgesehen von einem Fall mit Präazidose. Die Korrelation zwischen DI pro 30 min und pH des Nabelschnur-Arterien-Blutes ist hoch signifikant (Abb. 5 und 6). Die Korrelation zur APGAR-Punktezahl ist etwas geringer (Abb. 7 und 8).

Unsere Ergebnisse lassen eine prognostische Aussage mit Hilfe des DI zu: **Ist der DI pro 30 min geringer als 150 und liegen keine anderen FHF-Alterationen oder mütterliche Komplikationen vor, so können wir auf ein fehlendes Risiko für den Feten schließen; ist der Index über 200, besteht ein Risiko für den Feten und er wird fast immer mit einer Azidose geboren werden.** Die Werte zwischen 150 und 200 zeigen ein mittleres Risiko an und erfordern eine dauernde Überwachung (Tab. I).

Die Autoren weisen auf die Wichtigkeit hin, die dieser Index in dem Verständnis der kardiotokographischen Befunde hat. Besonders dann, wenn es aus apparativen oder technischen Gründen nicht möglich ist, Fetalblutanalysen durchzuführen.

Außerdem werden die durchschnittlichen Werte des DI in Abhängigkeit von der traditionellen Einteilung der fetalen Herzfrequenzmuster angegeben (Tab. III).

Schlüsselwörter: APGAR-Punktezahl, Dezelerationen, Dezelerationen, Dezelerations-Index, Fet, Herzfrequenz, Neugeborenes, Säure-Basen-Status, Tief.

Résumé

Index de décéleration (I.D.) de la fréquence cardiaque foetale et sa correlation avec le pH foetal, l.apgar score et les dips ou décélerations

Les auteurs du présent article proposent une méthode d'évaluation des décélérations de la fréquence cardiaque foetale (FCF) d'un usage pratique et simple et qui fournit des données numériques pouvant être mises en corrélation avec les conditions foetales et néonatales, indépendamment de la classification traditionnelle de ces décélérations ou Dips.

L'index de décélération comporte les paramètres suivants (**Fig. 1**): a) intervalle entre le début de la contraction et le début de la baisse de FCF, b) retard (lag time) entre le point culminant de la contraction et le point le plus bas de la décélération ou dip, c) durée de décroissance jusqu'au point où la FCF remonte vers sa valeur normale, et d) amplitude comptée en pulsations par minute. La somme de ces paramètres est divisée par 10.

42 femmes ont été observées en travail par monitoring (système de surveillance continue), à l'aide d'enregistrements cardiotocographiques et de prélèvements de spécimens du sang capillaire foetal. Après l'accouchement nous avons analysé aussi les conditions acido-basiques du sang ombilical et le score APGAR.

Durant les 30 minutes précédant chaque prélèvement sanguin et accouchement, nous avons évalué l' I.D. de chaque baisse transitoire et avons ajouté les valeurs des 30 minutes. **Fig. 2** nous voyons les changements du pH actuel dans chaque cas, selon le temps écoulé et la valeur de l' I.D./30 min. **Fig. 3 et 4** nous voyons la corrélation entre le pH actuel de chaque cas et l' I.D./30 min. et sa moyenne par contraction, avant chaque analyse. D'une façon générale, quand l'index de décélération augmente, le pH baisse et tous les cas qui avaient eu un I.D./30 min. supérieur à 200, se sont terminés par de l'acidose dans l'artère ombilicale à l'exception d'un seul avec préacidose. La corrélation entre l' I.D./30 min. plus élevé dans quelques-unes des périodes étudiées et le pH de l'artère ombilicale est très significative (**Fig. 5 et 6**). La corrélation avec le score APGAR est un peu plus basse (**Fig. 7 et 8**).

Selon ces études, les valeurs de pronostic de l'index de décélération sont les suivantes: **Si l'I.D./30 min. est inférieur à 150 et s'il n'y a pas d'autres altérations de la FCF ou maternelles, nous pouvons en déduire l'inexistence de risque pour le foetus; si l'index est supérieur á 200, il y a un risque pour le foetus qui naît presque toujours avec de l'acidose.** Les valeurs situées entre 150 et 200 indiquent un risque modéré et nécessitent donc une surveillance étroite (**Tab. I**).

Les auteurs insistent sur l'importance que peut avoir cet index dans l'interprétation des enregistrements cardiotocographiques foetaux, spécialement quand on ne dispose pas d'appareil pour les prélèvements microsanguins ou que ceux-ci sont impossibles pour des raisons techniques.

Les valeurs moyennes de l'index de décélération qui correspondent aux échantillons traditionnels de la FCF sont également indiquées (cf. **Tab. III**).

Mots-clés: Conditions acido-basiques foetales, décélérations de la FCF, dips, nouveau-né, fréquence cardiaque foetale, index de décélération (I.D.), score Apgar.

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